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Flood Control Section*

U. S. DEPARTMENT OF AGRICULTURE

FLOOD CONTROL

FIELD COORDINATING COMMITTEES

18 AND 20

PRELIMINARY EXAMINATION REPORT

SACRAMENTO AND SAN JOAQUIN
RIVER VALLEYS

KAWEAH - TULE RIVER GROUP

PUBLIC No. 738 APPROVED JUNE 26, 1936

REGIONAL WATER CONSERVATION DIVISION

E(RI)CAL
FCS
Kaweah-Tule Group

CONFIDENTIAL ADDENDUM TO PRELIMINARY FLOOD CONTROL REPORT ON
KAWEAH-TULE GROUP OF STREAMS, CALIFORNIA

The area covered by this investigation includes approximately 3200 square miles and embraces the drainage and dependent agricultural lands of the Kaweah River, Tule River, Deer Creek, Cottonwood Creek, and other tributary streams. A flood problem does exist in this area, as evidenced by the following facts:

History: Twenty-nine damaging floods have occurred in this area since 1862, or a frequency of approximately one in every three years. Insufficient data are available to determine the average annual monetary loss due to damages from floods.

Causes: Five factors are chiefly responsible for floods in this area, as follows:

1. High intensity of winter rains and rapid spring snow melt.
2. Sedimentation and aggradation of channels, resulting in inadequate flood flow capacities.
3. Depleted cover, principally caused by overgrazing and fire.
4. Severely eroded soils in the lower foothills.
5. Poor agricultural practices, particularly in foothill areas.

A. S. D. A. Lawrence 52432
3/14/39

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25432
6/14/64

Remedial measures proposed are listed in Memorandum No. 2 accompanying this statement.

Conclusion and Recommendation: It is the consensus of opinion of Department of Agriculture Flood Control Field Coordinating Committees 18 and 20 that there is a possibility of developing a feasible and technically sound program of waterflow retardation and soil erosion prevention in the watersheds of these streams.

It is therefore recommended that a detailed survey be authorized for the Kaweah-Tule Group of streams in California. Estimates of cost and features of such a detailed survey are covered in attached Memorandum No. 1. Suggested remedial measures are presented in attached Memorandum No. 2.

E. I. KOTOK, Co-Chairman

Forest Service
Field Coordinating Committees 18 & 20

HARRY E. REDDICK, Co-Chairman

Soil Conservation Service
Field Coordinating Committees 18 & 20

EDWIN E. WILSON, Member

Bureau of Agricultural Economics
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Bureau of Agricultural Economics

MEMORANDUM NO. 1

(To supplement Preliminary Flood
Control Report on Kaweah-Tule
Group of Streams - California)

(a) Estimated cost of detailed survey and report by all participating bureaus of the Department of Agriculture for approximately 2,048,000 acres: \$40,000.

(b) Estimated time required: 4 months.

(c) Character and extent of survey:

1. Field survey investigation and report on re-forestation, revegetation and upstream engineering measures required to correct existing watershed conditions.
2. Determination of improved land management practices required, particularly a proper range management program.
3. Determination of additional requirements necessary to provide adequate fire protection.
4. Determination of extent and type of soil conservation measures required on cultivated foothill lands.
5. Determination of the present occupancy and economy of the watershed.
6. Determination of the economic feasibility of the proposed program -- cost, benefit analysis.
7. Determination of the social and economic consequences of the proposed program, including institutional adjustments made necessary or resulting therefrom.

(To Supplement Preliminary Flood Control Report on Kaweah-Tule Group of Streams - California)

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5. Determination of the present occupancy and economy of the watershed.

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MEMORANDUM NO. 2

(To supplement Preliminary Flood Control
Report on Kaweah-Tule Group of Streams -
California.)

REMEDIAL MEASURES AND IMPROVEMENT PLAN ON THE BASIS OF PRE-
LIMINARY EXAMINATION.

The Department of Agriculture Flood Control Committees 18 and 20 consider the following measures essential to restore the watersheds of the Kaweah and Tule Rivers and other streams considered in this group to a favorable condition for the retardation of runoff, control of erosion, conservation of timber, with resultant effects toward the control of floods. Data available at the present time are insufficient to prepare even an approximate estimate of cost for the measures proposed. For this reason, no estimate of cost of the proposed remedial measures is included.

A. Direct measures for runoff and waterflow retardation and soil erosion prevention.

1. Regulatory measures.

- (a) Improved range management practices.
- (b) Organization of soil conservation districts
where required.
- (c) Generally improved land management and use
practices.
- (d) Increased measures and organization for fire
protection of high hazard areas.

(To supplement Preliminary Flood Control
Report on Kaweah-Tule Group of Streams -
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protection of high hazard areas.

2. Construction and cultural measures.

(a) Upstream engineering works of improvement as required.

(b) Sowing and planting on eroded lands and on deforested areas.

B. Land use measures

1. Convert present use of seriously eroding sub-marginal cultivated lands to less damaging use, areas to be determined by detailed survey.

C. Land management measures.

1. Reduce grazing intensity on areas seriously eroded by overgrazing.

D. Public acquisition of certain lands on which present abusive uses or practices constitute a hazard to proper management of the watershed.

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PRELIMINARY EXAMINATION REPORT

KAWEAH - TULE GROUP

PRELIMINARY EXAMINATION REPORT

KAWAHA - TULE GROUP

PRELIMINARY EXAMINATION REPORT

Runoff and Waterflow Retardation and Soil Erosion Prevention

KAWEAH-TULE GROUP

Kaweah River
Tule River
Cottonwood Creek
Deer Creek

Tributary to

#163 SACRAMENTO AND
SAN JOAQUIN RIVER VALLEYS

In compliance with

Section 6 of the Flood Control Act, June 22, 1936

Public No. 738 -- 74th Congress

FLOOD CONTROL FIELD COORDINATING COMMITTEES 18 AND 20

E. I. KOTOK
E. I. KOTOK, Co-Chairman

Forest Service
Field Coordinating Committees 18 & 20

HARRY E. REDDICK
HARRY E. REDDICK, Co-Chairman

Soil Conservation Service
Field Coordinating Committees 18 & 20

EDWIN E. WILSON
EDWIN E. WILSON, Member

Bureau of Agricultural Economics
Field Coordinating Committees 18 & 20

PRELIMINARY EXAMINATION REPORT

Runoff and Waterflow Retention and Soil Erosion Prevention

KAWASH-TULE GROUP

Kawash River
Tule River
Cottonwood Creek
Deer Creek

Tributary to

SAN JOAQUIN RIVER VALLEY
AND
SACRAMENTO

In compliance with

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Bureau of Agricultural Economics

EDWIN E. WILSON
EDWIN E. WILSON, Member

AUTHORITY

This report of preliminary examination is made in compliance with the Flood Control Act of June 22, 1936, Public No. 738 -- 74th Congress, as follows:

"Section 6 -- The Secretary of Agriculture is authorized and directed to cause preliminary examinations and surveys for run-off and waterflow retardation and soil erosion prevention on the watersheds of Sacramento and San Joaquin River Valleys, California."

RESEARCH REPORT

Report on the Investigation of the Causes of the Floods in the Sacramento and San Joaquin River Valleys

REPORT

James H. Hays

U.S. Army

AUTHORITY

Public Law 738

This report of preliminary examination is made in

compliance with the Flood Control Act of June 22, 1936,

Public No. 738 -- 7th Congress, as follows:

"Section 6 -- The Secretary of Agriculture is author-

ized and directed to cause preliminary examinations and surveys
for run-off and waterflow retardation and soil erosion prevention
on the watersheds of Sacramento and San Joaquin River Valleys,
California."

Forest Service

U.S. Department of Agriculture

Soil Conservation Service

U.S. Department of Agriculture

Division of Agricultural Research

U.S. Department of Agriculture

U.S. Army

U.S. Army

KAWEAH - TULE PRELIMINARY REPORT

Syllabus

The Department of Agriculture Flood Control Committee finds that a flood problem exists in the Kaweah and Tule watersheds; that the flood problem has been materially accentuated by silt derived from recently accelerated erosion in the watersheds; that erosion has been accelerated by the abuse of land and the destruction of natural cover; that erosion sore spots can be healed with benefit to the watersheds and a corresponding reduction of flood damages from silting; and that protective measures for the watershed will probably be economically justified. A detailed survey is therefore recommended.

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LOCATION MAP
Showing Watershed
of
Kaweah - Tule Rivers



I. DESCRIPTION

Geographic Location and Physiography

1. The Kaweah-Tule River Group of watersheds is located in the southern end of the Great Central Valley of California, and is bounded by the Kings River drainage on the north and that of the Kern River Group on the east and south. It includes Cottonwood Creek, Kaweah and Tule River, and Deer Creek, with their tributaries. These are companion streams rising at intervals along secondary ridges, on the western slope of the Sierra Nevada Range.
2. The Group covers an area of approximately 3200 square miles, of which 2000 lie on the gently sloping floor of the San Joaquin Valley, and 1200 in the foothills and mountains. Of the latter area some 500 square miles are in the Kaweah watershed, about 400 in the Tule, and the balance of 300 in the other smaller drainages.
3. The Kaweah River originates in glacial lakes and the Tule River in rugged terrain bordered by peaks reaching above 11,000 feet in elevation. Their waters flow westerly through deeply cut channels to the San Joaquin Valley where they are normally used or dissipated in a large number of small delta channels. During periods of heavy floods, the flow reaches Tulare Lake about 25 miles southwest of Visalia. This lake is the natural receiving basin for flood waters of the Kaweah-Tule, Kings and Kern River groups of streams. Outflow from Tulare basin to the San Joaquin River occurs only at rare intervals, in years of exceptionally high precipitation.

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4. The channels in the mountainous portions of the watershed are in general well defined and have sufficient capacities to carry flood flows, but in the valley areas they become broader with shallower banks, and in many instances sand and gravel deposits as well as riparian vegetation have materially reduced their capacity.

5. Geology and Soils

The mountainous portions of the group are composed largely of various phases of granitic and metamorphic rocks and soils derived therefrom, which together constitute 47% of the basin area. The granitic rocks predominate. They are often deeply weathered, and in many areas have formed soils that are light and sandy in character, constituting some of the more highly erodible soils in the Sierra Nevada. In contrast, the metamorphic rocks are indurated and are highly resistant to erosion, producing soils that are heavier textured and somewhat less erodible.

6. Soils of the San Joaquin Valley below the mountainous areas cover about 53% of the basin and are broadly classified as:

- I - Highly permeable, recent alluvial - 26% of area
- II - Relatively impermeable secondary, developed on old alluvial deposits - 21% of area; and
- III - Highly impermeable, indurated hardpan soils developed on old secondary fan deposits - 6% of area.

7. The approximate boundaries of the various soil groups are shown on map No. 2. This map also indicates the critical erosion and flood source areas which will be discussed under their paragraph headings.

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The approximate boundaries of the various soil groups are shown on map No. 2. This map also indicates the critical erosion and flood source areas which will be discussed under their proper headings.

II. OCCUPANCY AND ECONOMY

Population

8. Population is concentrated mainly on the San Joaquin Valley floor (see Map No. 3), centering about the towns of Visalia, Porterville, Lindsay and Exeter. It is estimated that the total population of the watershed area is 78,000 persons, of which 40,000 are urban, 29,000 are rural farm, and 9,000 are rural non-farm. Of this number about 1,200 rural residents are located in areas subject to average floods and about 3,000 reside in areas inundated by extreme floods. In addition the towns of Visalia, with 8,730 people, and Porterville, with 6,374, are located in the paths of floods but protective works saved them from damage from the 1937 flood.

9. A steady increase in population is being experienced, due chiefly to the influx of drought refugees from middlewestern States. This increase is causing closer settlement of the areas subject to flooding.

Land Ownership and Use

10. Eighty-five per cent of the total area is privately owned, and the remaining 15% is public land in the following categories: National Forest approximately 6%; National Park 7%; Indian Reservation 2%, and a small fraction State lands. (See Map No. 5). On the valley floor, where the land is cropped intensively, holdings are usually in small blocks, but in the foothill sections where grazing is the principal use, holdings are larger, one single unit being 92,000 acres in extent. Census data reveal a significant increase in the number of farms under 10 acres and over 1000, while at the same time there has been a decrease in

II. OCCUPANCY AND ECONOMY

Population

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Land Ownership and Use

Ninety-five per cent of the total area is privately owned,

and the remaining 5% is public land in the following categories: National Forest approximately 6%; National Park 1%; Indian Reservation 2%, and a small fraction State lands. (See Map No. 5).

On the valley floor, where the land is cropped intensively, holdings are usually in small blocks, but in the foothill sections

where grazing is the principal use, holdings are larger, one single unit being 92,000 acres in extent. Census data reveal a significant increase in the number of farms under 10 acres and over 1000, while at the same time there has been a decrease in

the remainder of the groups. There is also a decrease in the total number of farms, due in part to water shortage and the consequent abandonment of farms in localities dependent upon pumped groundwater.

11. Approximately 55% of the basin area, or roughly 1,130,000 acres, are devoted to agriculture. About 85% of the land in crops is irrigated. For location of irrigation districts and areas under irrigation, see Map No. 6. Predominant crops include cotton, grapes, alfalfa, grains, citrus and deciduous fruits. The cotton acreage has increased continuously during the past five years; it expanded from 81,800 acres in 1936 to 144,000 acres in 1937, an increase of 77% in two years. Fifty-five per cent of the crop acreage is soil depleting, 26% soil conserving and 19% neutral. Map No. 7 indicates the type of farming on agricultural lands.

12. Since about 1880 grazing of cattle and sheep has been the predominant use in the woodland-grass and grassland cover types of the foothill and mountainous areas which represent about 21% of the basin area. Logging has been confined to a few small areas in the pine-fir cover types in the high Sierras, and is not significant from a watershed standpoint. Table 1, page 6 broadly summarizes the natural cover, major land use and ownership, and Map No. 7 portrays the cover types.

13. The value of farm land and buildings in this area varies from an average of \$500 an acre and \$30,000 per farm in the citrus areas to an average of approximately \$15 per acre and \$20,000 per farm in the foothill sections. The estimated total value of all farm land and buildings is \$85,240,000.

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11. Approximately 75% of the basin area, or roughly 1,130,000 acres, are devoted to agriculture. About 8% of the land in crops is irrigated. For location of irrigation districts and areas under irrigation, see Map No. 6. Predominant crops include cotton, grapes, alfalfa, grains, citrus and deciduous fruits. The cotton acreage has increased continuously during the past five years; it expanded from 81,800 acres in 1936 to 144,000 acres in 1957, an increase of 77% in two years. Fifty-five per cent of the crop acreage is soil depleting, 26% soil conserving and 19% neutral. Map No. 7 indicates the type of farming on agricultural lands.

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14. The gross farm income on cultivated land is approximately \$100 an acre or \$6,000 per farm, while stock ranches average a return of about \$6.00 per acre or \$10,000 per holding.
15. In the main, Tulare County income is derived from agriculture. A minor source of income is manufacturing, which is confined chiefly to the processing of agricultural products. Estimated receipts from both these sources for 1936 were \$30,000,000. Tax rates and tax delinquencies are both low. Mortgage indebtedness is high in the intensively cropped sections. Lands subject to floods are assessed at approximately one-half the rate of similar adjacent lands not subject to floods.
16. Rail communication in the San Joaquin Valley area of the basin is furnished by main and branch lines of the Southern Pacific and Santa Fe Railroads. The principal highway is U.S. 99, which parallels the main line Southern Pacific tracks. Traffic counts made at Tulare show that during the 1938 spring flood season, this highway carried an average of about 8,000 vehicles per twenty-four hours. Approximately 3,300 miles of roads serve the Kaweah and Tule watersheds, of which 3,000 miles are improved, 200 unimproved, and 100 are primary State highway.

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TABLE 1

NATURAL COVER, MAJOR LAND USE AND OWNERSHIP

Total Basin Area = 3,200 square miles

Natural Cover		:	:	:
		:	Major Land Use	Major Ownership
Classification	Per Cent	:		
	Basin Area:	:		
Forested lands (Conifer)	15	:	Water production, grazing, recreation.	Public
Brush lands	9	:	Water production	Public and private
Woodland-grass and grasslands	21	:	Grazing	Private
Agricultural lands (chiefly valley lands)	55	:	Irrigated crops and dry farming	Private
TOTALS	100	:		Private 85% Basin Public 15% Basin

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Forested lands (Conifer)	15	Water production, Public	Water production, Private	Public	Private
Brush lands	9	Grassland, reserved	Grassland, reserved	Public and private	Public and private
Woodland-grass and grasslands	21	Grassland	Grassland	Private	Private
Agricultural lands (chiefly valley lands)	55	Irrigated crops and dry farming	Irrigated crops and dry farming	Private	Private
TOTALS	100	Private 85% Basin	Public 15% Basin	Private 85% Basin	Public 15% Basin

III. HYDROLOGY

17. Precipitation

Precipitation occurs chiefly during the months from November to May, with the average seasonal total ranging from about 8 inches at Tulare (elevation 285 feet) to 37 inches at Giant Forest (elevation 6,360 feet), with greater amounts occurring at higher elevations. In the watershed area above 5,000 feet, precipitation usually is in the form of snow, creating a reservoir which in normal years liberates water slowly during the spring and summer months.

18. Floods

The floods occurring in this basin are similar to those experienced in other east side San Joaquin Valley drainages in that they are of two types. The first, a flash type, ordinarily caused by high intensity rains on the foothill areas, occurring during the winter months and characterized by high peaks and short durations, seldom exceeds 36 hours. The second, a spring flood type, usually is caused by melting of the seasonal snow pack in the upper Kaweah and Tule watersheds and characterized by lower peaks than the flash type, but lasting for a longer period of time, usually between two and four weeks.

19. The winter flash floods can cause inundation of large areas and widespread damage. Such a flood occurred on December 10, 1937 as a result of an exceptionally severe storm. This storm was general throughout the State and resulted in record flows in many streams.

III. HYDROLOGY

Precipitation

Precipitation occurs chiefly during the months from November to May, with the average seasonal total ranging from about 8 inches at Telara (elevation 285 feet) to 37 inches at Giant Forest (elevation 6,500 feet), with greater amounts occurring at higher elevations. In the watershed area above 5,000 feet, precipitation usually is in the form of snow, creating a reservoir which in normal years liberates water slowly during the spring and summer months.

Floods

The floods occurring in this basin are similar to those experienced in other east side San Joaquin Valley drainages in that they are of two types. The first, a flash type, ordinarily caused by high intensity rains on the foothill areas, occurring during the winter months and characterized by high peaks and short durations, seldom exceeds 36 hours. The second, a spring flood type, usually is caused by melting of the seasonal snow pack in the upper Keweenaw and Tule watersheds and characterized by lower peaks than the flash type, but lasting for a longer period of time, usually between two and four weeks.

The winter flash floods can cause inundation of large areas and widespread damage. Such a flood occurred on December 10, 1937 as a result of an exceptionally severe storm. This storm was general throughout the State and resulted in record flows in many streams.

The peak flow on the Kaweah amounted to 33,300 second feet, being the greatest of published record, however the 24 hour flow for this day is 10,800 second feet. This mean 24 hour flow has been exceeded once in the period of record, February 6, 1937 (13,000 second feet) and nearly equalled on several occasions.

20. This same storm caused a peak flow on the Tule River (above South Fork) of 11,300 second feet. This peak flow has been exceeded twice during the period of record, February 13, 1936 and February 6-7, 1937. It is notable that the maximum 24 hour flow for December 10-11, 1937 was only 2,880 second feet. This flow has been exceeded nineteen times of record, and nearly equalled seven times.

21. Flash floods are potentially very damaging, as these sudden flows overtax the capacities of channels, levees and other structures. When such floods occur, the damage is more severe in upper areas, causing damage to roads, highways, bridges and municipalities.

22. The spring floods usually do not cause as much damage by inundation of cities and lands adjacent to the stream channels as do the winter flash floods, but may, during seasons of excessive runoff, aggravate the flood condition in Tulare Lake basin, which would be receiving coincidentally large volumes of flood water from the Kings and Kern River basins.

23. Engineers reported at the hearing that floods have occurred on the Kaweah Delta, affecting Visalia and adjacent areas, in 1862,

The peak flow on the Kaweah amounted to 35,300 second feet, being
 the greatest of published record, however the 24 hour flow for
 this day is 10,800 second feet. This mean 24 hour flow has been
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 water from the Kings and Kern River basins.
 Engineers reported at the hearing that floods have occurred
 on the Kaweah Delta, affecting Visalia and adjacent areas, in 1862,

1868, 1875, 1879, 1906 (two floods), 1916 and 1937. In addition to these years, flood conditions prevailed in 1938, giving a flood occurrence of about one in ten years. The floods of 1868 and 1862 were reported of greater extent and volume than any of record. It is unknown how these earlier floods compare with those of 1937-38. Local engineers estimated a flood frequency for the Tule River as once in ten years and on Deer Creek as once in twenty-five years.

24. A typical hydrograph, shown on page 9A, for the season 1936-37, indicates the two types of floods to be expected from the Kaweah and the main Tule River above the South Fork.

Groundwater Conditions

25. At the present time the chief source of irrigation waters for most of this area is the underground reservoirs. A very large portion of the agricultural area is now almost wholly dependent upon this underground supply.

26. During periods of sub-normal rainfall there has been a general recession of water levels in the agricultural areas, and at some locations pumping has reached economical limits and farms have been abandoned.

27. In contrast to this condition a series of above-normal years has produced in some areas a rise of groundwater levels to such a point that orchards have been killed due to high water table.

28. Figures are not available to determine with accuracy the amount and distribution of such fluctuations, but it is known that

1868, 1875, 1879, 1906 (two floods), 1916 and 1937. In addition to these years, flood conditions prevailed in 1938, giving a flood occurrence of about one in ten years. The floods of 1868 and 1869 were reported of greater extent and volume than any of record. It is unknown how these earlier floods compare with those of 1937-38. Local engineers estimated a flood frequency for the Tule River as once in ten years and on Bear Creek as once in twenty-five years.

A typical hydrograph, shown on page 9A, for the season

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the problem of two extremes of conditions occurs in this area.

It is obvious that some control is needed and that a study is required to determine the best methods of regulating this extreme fluctuation so that the agricultural industry and land values can be stabilized.

Turbidity

29. Information as to the amount of silt carried by the stream is not available, but reports by engineers submitted at the Bakersfield hearing show that there is a problem in the river channels due to sanding and silting which makes dredging and building up of levees and banks necessary.

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of levees and banks necessary.

IV. FLOOD DAMAGE AND EROSION LOSS

Flood Damage

30. In the past the principal flood damage to agriculture has been through the inundation of cultivated lands in the region of Tulare Lake, the breaking of levees, and the sedimentation of irrigation canals serving the valley areas. Estimates of damage are summarized in Table 3 following, and the areas subject to flooding are outlined on Map No. 4.

TABLE 3

1937 FLOOD DAMAGES KAWEAH-TULE RIVER GROUP*

Damage	:	Amount
Crops and pasture	:	\$ 55,800
Municipal and industrial	:	22,800
Bridges, railways, highways	:	123,200
Rural property and improvements	:	21,600
Livestock losses	:	3,900
Intangible - loss of time; marketability, spread of noxious weeds	:	12,400
	:	
TOTAL	:	\$ 239,700
	:	
Loss of life - 2 persons	:	

* Reclassified from data supplies by War Department.

31. In addition to the damages tabulated it is estimated that damage to land through the removal of soil or deposition of sediments during the spring and fall of 1937 totals \$40,000. Adequate data are not available as to the losses occasioned during the December 1937 floods and the floods which occurred from the seasonal run-off. However, these damages are known to be large.

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TABLE 3

1937 FLOOD DAMAGES KAWAR-TULI RIVER GROUP*

Amount	Damage
\$ 55,800	Crops and pasture
55,800	Municipal and industrial
123,200	Bridges, railways, highways
21,600	Rural property and improvements
3,900	Livestock losses
12,400	Intangible - loss of time; marketability, spread of noxious weeds
\$ 239,700	TOTAL
	Loss of life - 5 persons

* Reclassified from data supplied by War Department.

In addition to the damages tabulated it is estimated that damage to land through the removal of soil or deposition of sediments during the spring and fall of 1937 totals \$40,000. Adequate data are not available as to the losses occasioned during the December 1937 floods and the floods which occurred from the seasonal run-off. However, these damages are known to be large.

Erosion Losses

32.

Erosion conditions for the watershed as a whole are shown on Map No. 8 and are summarized in Table 4, page 13. Nineteen per cent of the area is affected by serious accelerated erosion principally in the foothill regions on residual soils formed on granitic and metamorphic rocks. This erosion has been induced primarily by overgrazing of the range lands (see photograph No. 1A) and occasionally by fire. In addition fire has destroyed the protective chaparral cover on small areas of middle watershed slopes in the upper Kaweah and Tule Basins, aggregating some 19,000 acres. The sandy granitic soils thus exposed are among the more erodible of any in the Sierra Nevada Range and are producing significant quantities of erosion debris. Since 1910, 20% of the mountainous area has been burned, and of this only 2% reburned. The burned areas are shown on Map No. 9.

33.

Eighty per cent of the basin area does not present a significant erosion problem. Erosion therein is classified as "none or slight" and "moderate". The "moderate" includes approximately 112,000 acres of cultivated lands situated principally on secondary soils occurring along the valley-foothill transition zone. The locations of critical erosion areas are shown on Map No. 2. Table 5, page 14 shows the distribution of various soil groups and indicates their relation to floods and erosion.

34.

Although not of sufficient total magnitude to warrant classification in Table 4, it should be noted that lateral erosion and bank caving are characteristic of many of the foothill streams, such as Wood and Yokohl Creeks. This is illustrated by Photograph 1B, page 12A. Poor road drainage practices are responsible for small areas of localized erosion, as illustrated in Photograph 2, page 12B.

32. Erosion conditions for the watershed as a whole are shown on Map No. 3 and are summarized in Table 4, page 15. Nineteen per cent of the area is affected by various accelerated erosion principally in the foothill regions on residual soils formed on granitic and metamorphic rocks. This erosion has been induced primarily by overgrazing of the range lands (see photograph No. 1A) and occasionally by fire. In addition fire has destroyed the protective chaparral cover on small areas of middle watershed slopes in the upper Kaweah and Tule Basins, aggregating some 19,000 acres. The sandy granitic soils thus exposed are among the more erodible of any in the Sierra Nevada Range and are producing significant quantities of erosion debris. Since 1910, 20% of the mountainous area has been burned, and of this only 2% returned. The burned areas are shown on Map No. 9. Eighty per cent of the basin area does not present a significant erosion problem. Erosion therein is classified as "none or slight" and "moderate". The "moderate" includes approximately 112,000 acres of cultivated lands situated principally on secondary soils occurring along the valley-foothill transition zone. The locations of critical erosion areas are shown on Map No. 2. Table 5, page 14 shows the distribution of various soil groups and indicates their relation to floods and erosion.

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1A Severe gully erosion on overgrazed slopes in Limekiln Creek drainage. Slope gradient is approximately 60% medium textured residual soil.



1B Severe active gully erosion at base of slope shown in Photo No. 1A. Erosion accelerated by stream bank cutting. Limekiln Creek in foreground has been scoured to bedrock in this section. Gullies along stream bank average 6 feet wide, 8 feet deep, 40 feet long.



1A Severe gully erosion on overgrazed slopes in limestone
Greek drainage. Slope gradient is approximately 60%
medium textured residual soil.

1B Severe active gully erosion at base of slope shown in photo
No. 1A. Erosion accelerated by stream bank cutting. Lime-
stone Creek in foreground has been scoured to bedrock in
this section. Gullies along stream bank average 6 feet
wide, 8 feet deep, 40 feet long.



2. Severe gully erosion on open woodland grass range in Yokohl Valley. Caused by inadequate road drainage, augmented by overgrazing.



WELBAC PHOTO

The picture was taken at the mouth of the Waialeale River, looking out over the water towards the distant shore.

PHOTO BY WELBAC

COURTESY

HAWAIIAN FOREST & RANGE EXPERIMENT STATION
U. S. FOREST SERVICE

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2. Severe gully erosion on open woodland grass range in Yokoh Valley. Caused by inadequate road drainage, augmented by overgrazing.

TABLE 4
DISTRIBUTION OF EROSION*

MAP No. 8

Erosion Classification	Acres (Rounded)	Per Cent of Basin Area
None or slight	1,117,000	54
Moderate	446,000	22
Moderately severe and severe	377,000	19
Geologic	77,000	4
Wind**	20,000	1
TOTAL	2,037,000	100

* The terms slight, moderate, etc., refer to the critical nature of erosion from a flood control standpoint. These terms are based on observation only of soil slope, cover and land use. They do not involve tests or measurements and do not represent the percentage of topsoil removed.

** Partially stabilized. Includes 3,000 acres of dunes over 6 feet.

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TOTAL	2,037,000	100

* The terms slight, moderate, etc., refer to the critical nature of erosion from a flood control standpoint. These terms are based on observation only of soil slope, cover and land use. They do not involve tests or measurements and do not represent the percentage of topsoil removed.

** Partially stabilized. Includes 7,000 acres of dunes over 6 feet.

TABLE 5

DISTRIBUTION OF SOIL GROUPS

Basin Area - 3,200 square miles

Group: No. :	Soil Group	: Per : : Cent: : Basin:	Principal Location	: Influences on Floods and Erosion
IV :	<u>Residual</u> on granite and metamorphic rocks	: 43 :	: Major portion upper watershed	: Granitic type is highly erosible and source of large quantities of sand.
I :	<u>Recent alluvial</u> , highly permeable	: 26 :	: Lower valley areas and alluvial fans	: Rapidly absorbs water and aids replenishment of underground supplies. Usually affected by deposition rather than erosion.
II :	<u>Secondary</u> , relatively impermeable, developed on old alluvial deposits	: 21 :	: Large portion valley floor and low rolling foothills	: Foothill areas produce high runoff and silt when depleted cover induces erosion.
III :	<u>Hardpan secondary</u>	: 6 :	: Foothill areas	: Highly impermeable. High runoff. Source of silt and sand in small area in Cottonwood and Limekiln Creeks.
V :	<u>Rock Outcrops</u> , glaciated cirques and domes	: 4 :	: Upper reaches Kaweah watershed.	: Occurrences at lower elevation source area for floods from rapidly melting snow; higher areas little contribution to flood flows.

V. FLOOD PROBLEMS AND REMEDIAL MEASURES

Flood Problems

35. The Kaweah-Tule River Group, like the neighboring Kings and Kern, is confronted with flood conditions originating from rapid melting of the seasonal snow pack and from flash floods caused by high intensity winter rains on the foothill areas.
36. Watershed protection measures are necessary in a comprehensive flood control program. Accelerated erosion, in addition to destroying the watershed land, contributes silt which is transported by all floods and is eventually deposited in the stream channels, in irrigation facilities, and on the valley floors, thus accentuating the flood problem. If major structures were installed for the reduction of flood damages and water conservation, continued silt movement would materially reduce their effectiveness and increase their maintenance cost. This accelerated erosion has been primarily induced by overgrazing, by cultivation and fire to a moderate degree, and by poor road drainage practices to a minor degree. All these conditions can be remedied to a large extent, and until this is done the values affected will be increasingly jeopardized.

Remedial Measures

37. (1) Initiation of a proper range management program.
- (2) Planting and mechanical control of severely gullied areas in the foothills and mountainous regions.
- (3) Introduction of soil conservation measures on cultivated foothill lands.
- (4) Adequate fire protection of the area.
- (5) Stabilization of eroding stream channels and roads by engineering works and planting.

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- (5) Stabilization of eroding stream channels and roads by engineering works and planting.

38. The Army Engineers suggest that adequate flood control on the Tule River would involve construction of a retarding reservoir and certain channel improvements, and that such improvements are economically justified. A watershed program, in addition to preserving upstream values which are highly significant, would add materially to the life and proper functioning of such downstream installations. A coordinated program of watershed and downstream measures would reduce direct and indirect flood damage to a minimum, allow more intensive use of about 31,000 acres of highly productive agricultural land, appreciate the assessed value of the area considerably, conserve flood waters by adding considerable quantities to the receding ground water supplies, prevent the spread of noxious weeds, reduce the pollution of domestic water supplies, prevent the spread of disease in the flooded area, and result in a higher economy for the entire region.

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49H7 View of damage to fish hatchery near Kaweah Power Plant # 1. Main building saved when stream was deflected by large pile of drift above it. Storm of December 1937.



49H5 Bridge washout on North Fork of Kaweah River at Three Rivers. Storm of December 1937.



View of damage to fish hatchery near Kawash Power Plant #1. Main building saved when stream was deflected by large pile of drift above it. Storm of December 1937.



Bridge washed out on North Fork of Kawash River at Three Rivers. Storm of December 1937.

KAWEAH-TULE BASIN



48H5 Typical view of peach orchard killed by rising groundwater, one mile north of Visalia. Orchard being uprooted.



48H7 Typical flooded area view. Walnut grove, house and highway flooded, northeast of Visalia. Storm of December 1937.



4885 Typical view of peach orchard killed by rising groundwater, one mile north of Visalia. Orchard being uprooted.



4887 Typical flooded area view. Walnut Grove, house and highway flooded, northeast of Visalia. Storm of December 1937.

VI. PROJECTS OF OTHER AGENCIES

39. There is no existing War Department project in the area under consideration, although the U. S. Engineer Department recommended in their 1938 preliminary examination report that the Kaweah and Tule Rivers be included in the flood control survey of the Sacramento and San Joaquin River Valleys, and a survey has been authorized.
40. According to information gathered by the U. S. Engineer Department, approximately \$79,000 has been spent by local interests on channel work and levees along the Kaweah River in the vicinity of Visalia. These levees gave protection to the city in December 1937, when they experienced the greatest flood of record, although they were nearly over-topped. Construction of a control weir and levees on the Tule River has recently been completed by the City of Porterville at an estimated cost of \$3,000. Although flood menace to the city will be greatly reduced, local interests feel that this is not adequate. Other channel and levee works costing some \$13,000 have been installed at various locations along the Tule River for protection of property in the vicinity of Woodville, but this work is believed inadequate.
41. Federal relief agencies have expended some \$59,000 for flood control works on the Kaweah and Tule Rivers. The summary of these expenditures is contained in Table 6.

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TABLE 6

1934-36 EXPENDITURES FOR FLOOD CONTROL KAWEAH AND TULE RIVERS

Sponsor	Federal Agency	Projects	Expenditure of Federal Agency	Expenditure of Local Interests	Total Expenditures
Tulare County and Kaweah River Assn.	SERA	Kaweah River Flood Control	\$ 31,057	\$ 3,750	\$34,807
City of Visalia and Tulare County	SERA	do	5,181	1,188	6,369
Tulare County Levees Dist. No. 1	SERA	do	1,970	525	2,495
Tulare County Levee Dist. No. 1	CWA	do	1,650	850	2,500
Tulare County Levee District No. 1	WPA	do	3,162	914	4,076
Tulare County*	WPA	Tule River Flood Control	6,454	2,879	9,333
			\$ 49,474	\$ 10,106	\$59,580

* Estimated - Project temporarily discontinued.

TABLE 6

1934-36 EXPENDITURES FOR FLOOD CONTROL KAWASH AND TULARE RIVERS

Sponsor	Agency	Project	Agency	Interests	Expenditure: Local	Expenditure: Total
Tulare County and Kawash River Assn.	SEWA	Kawash River: Flood Con- trol	\$ 31,057	\$ 3,750	\$34,807	
City of Visalia and Tulare County	SEWA	do	2,181	1,188	6,369	
Tulare County Levees Dist. No. 1	SEWA	do	1,970	225	2,195	
Tulare County Levee Dist. No. 1	CWA	do	1,650	850	2,500	
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Tulare County* Flood Control	WPA	Tule River: Flood Control	6,454	2,879	9,333	
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VII. ATTITUDE AND DESIRES OF LOCAL PEOPLE

A. Tule Lake Area

42. Due to fluctuation and general decrease of underground water supply, it is the hope of Tulare County residents that the Central Valley Water Project will be ultimately completed. It is desired that the present water supply contributing to groundwater be left intact.

43. At the request of the Tulare County Board of Supervisors, engineers submitted reports of conditions and suggested examinations or studies of certain remedial measures, as follows:

B. Kaweah Delta

44. It was stated in the engineers' report that in any method of control adopted there must be adequate attention given to conservation of flood waters and not of disposing of these waters in the fastest way. Provision must be made for storage, either surface, underground, or both. Probably the cheapest and most effective method of protection is channel improvement and water spreading. Silting has made a certain amount of dredging necessary. The complete problem of flood control must be studied, keeping in mind water conservation.

C. Tule River and Deer Creek

45. In this area the type of flood control desired is that which would both regulate and conserve water supply. It was thought that the proposed ultimate program of the Central Valley Water project will also control floods. It was stated that it is apparent that existing water rights in this area make it necessary that a complete study be made to harmonize all interests.

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VII. RECOMMENDATIONS

46.

Preliminary examination of the Kaweah-Tule Group of watersheds indicates that a flood and erosion problem exists, and that improvements in the watershed are necessary for the reduction of flood flows and sedimentation and for the retardation of run-off and control of erosion. Water conservation is of great importance and must be considered in connection with any improvements planned for flood control.

47.

It appears that measures for run-off and waterflow retardation and soil erosion prevention are feasible and economically justified. It is therefore recommended that a detailed survey be authorized.

SACRAMENTO AND SAN JOAQUIN VALLEYS NO. 163

KAWEAH-TULE RIVER GROUPS

CALIFORNIA

CRITICAL AREAS AND SOILS MAP

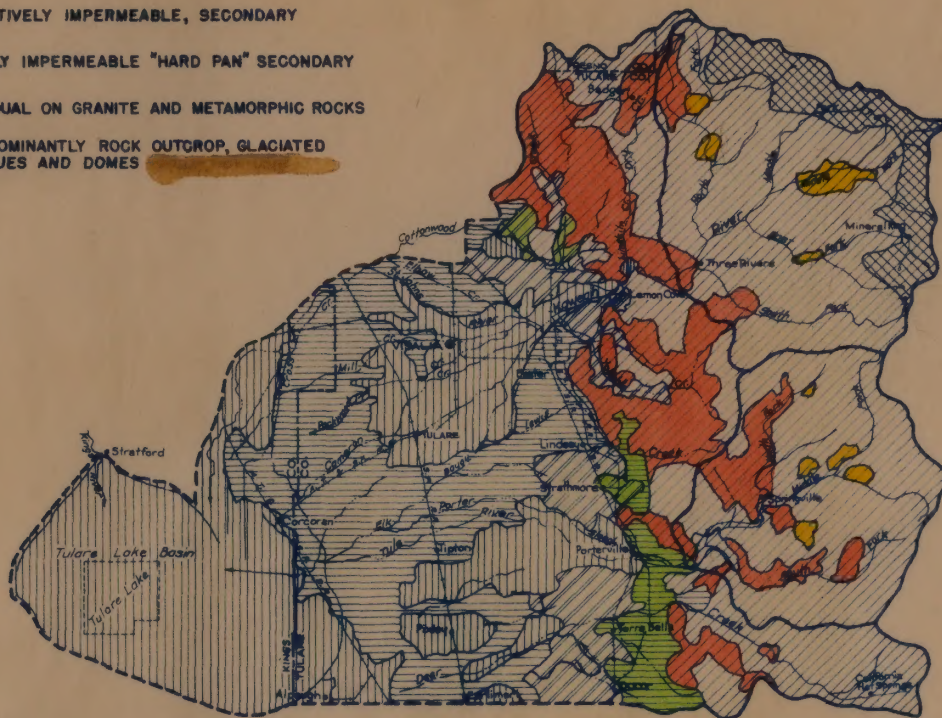
LEGEND

CRITICAL AREAS

- SEVERE EROSION ON CHAPARRAL COVERED WATERSHED SLOPES - LIGHT TEXTURED SANDY SOIL - SOURCE AREAS OF EXCESSIVE AMOUNTS OF SAND
- EROSION A PROBLEM ON RANGE LAND - GENERALLY OVERGRAZED HIGH SILT AND RUN-OFF - SOURCE AREAS OF EXCESSIVE AMOUNTS OF SAND.
- MODERATE EROSION PROBLEM ON CULTIVATED LANDS

SOILS

- HIGHLY PERMEABLE, RECENT ALLUVIAL
- RELATIVELY IMPERMEABLE, SECONDARY
- HIGHLY IMPERMEABLE "HARD PAN" SECONDARY
- RESIDUAL ON GRANITE AND METAMORPHIC ROCKS
- PREDOMINANTLY ROCK OUTCROP, GLACIATED CIRQUES AND DOMES



SCALE IN MILES
0 5 10



LOCATION MAP

- Boundary of Watershed.
- - - Boundary of Area affected by Water from Watershed.

E. I. KOTOK, CHAIRMAN, FIELD COORDINATING COMMITTEE NO. 18
HARRY E. REDDICK, CHAIRMAN, FIELD COORDINATING COMMITTEE NO. 20

U. S. DEPARTMENT OF AGRICULTURE
FLOOD CONTROL PUBLIC NO. 738

PROJECT NO. 163 MAP NO. 2
SOURCE OF DATA U.S.F.S. - SCS RECONNAISSANCE
CONSERVATION SURVEY

COMPILED BY S.C.S. DATE 1938

BUREAU S.C.S. - U.S.F.S. U.S.F.S.
APPROVED BUREAU S.C.S.

E. I. Kotok
Harry E. Reddick 159

SACRAMENTO AND SAN JOAQUIN VALLEYS NO. 163 KAWeah-TULE RIVER GROUPS CALIFORNIA CRITICAL AREAS AND SOILS MAP

LEGEND CRITICAL AREAS

- SEVERE EROSION ON CHANNELS COVERED INTERMEDIATE SLOPES - LIGHT TEXTURED SANDY SOIL - SOURCE AREAS OF EXCESSIVE AMOUNTS OF SAND
- EROSION A PROBLEM ON RAINFALL LAND - GENERALLY OVERGRAZED HIGH SILT AND RUN-OFF - SOURCE AREAS OF EXCESSIVE AMOUNTS OF SAND
- MODERATE EROSION PROBLEM ON CULTIVATED LANDS

SOILS

- HIGHLY PERMEABLE, RECENT ALLUVIAL
- RELATIVELY IMPERMEABLE, SECONDARY
- VERY IMPERMEABLE, HARD PAN, SECONDARY
- RESIDUAL ON GRAVEL AND METAMORPHIC ROCKS
- PROFOUNDLY ROCK OUTCROPS, BLOTTED CROOKS AND COMES



LOCATION MAP

U.S. DEPARTMENT OF AGRICULTURE
 FLOOD CONTROL PUBLIC WORKS
 PROJECT NO. 163
 SOURCE OF DATA: U.S. DEPARTMENT OF AGRICULTURE
 COMPILED BY: [Name]
 DATE: [Date]
 SCALE: 1:50,000
 MAP NO. 163
 TITLE: CRITICAL AREAS AND SOILS MAP
 AREA: SACRAMENTO AND SAN JOAQUIN VALLEYS
 GROUP: KAWeah-TULE RIVER GROUPS
 STATE: CALIFORNIA

SACRAMENTO AND SAN JOAQUIN VALLEYS NO. 163

KAWEAH - TULE RIVER GROUPS

CALIFORNIA

POPULATION

POPULATION OF URBAN CENTERS 1935*

URBAN CENTERS POPULATION

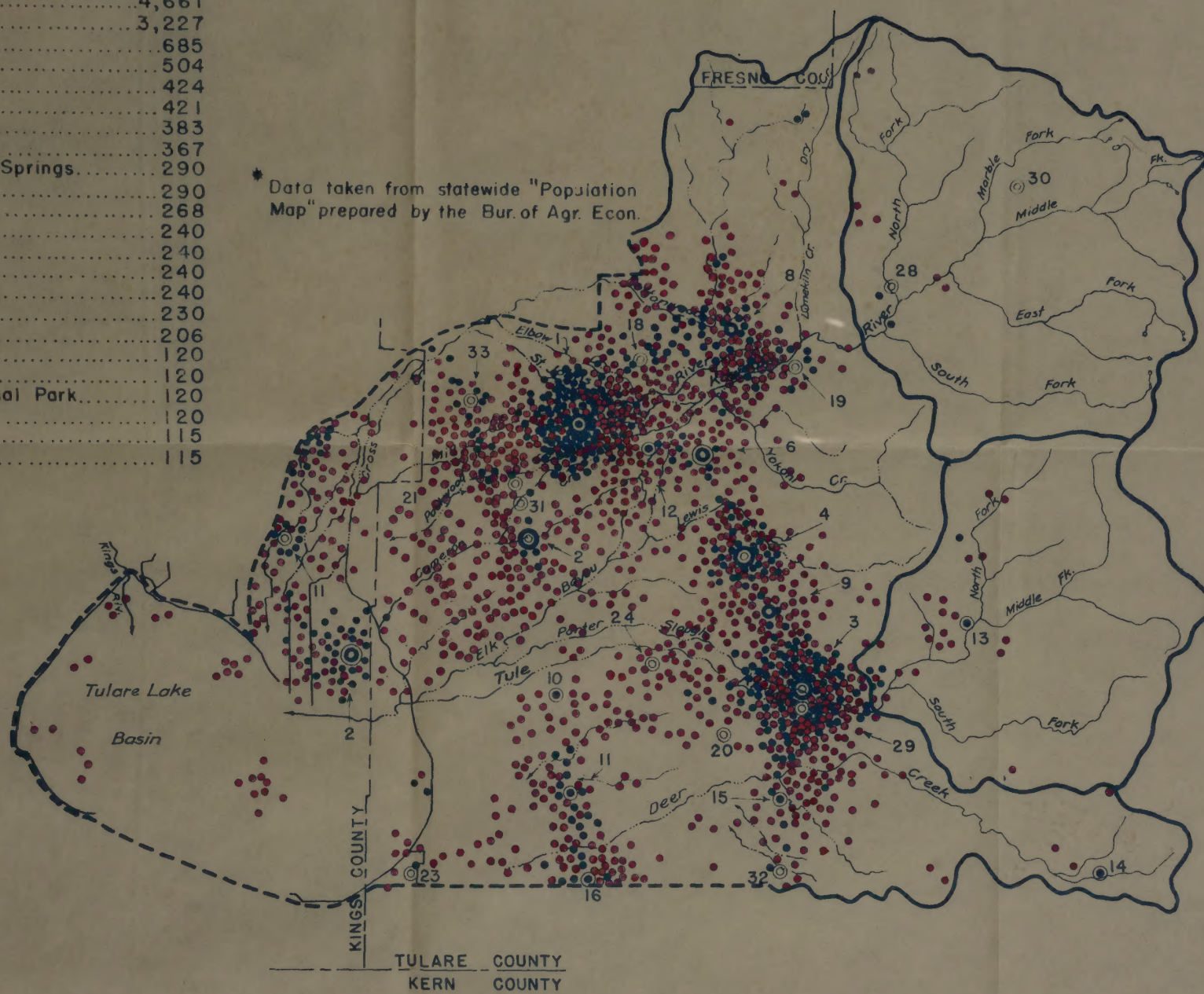
KINGS COUNTY

2	Corcoran.....	2,074
11	Guernsey.....	129

TULARE COUNTY

1	Visalia.....	8,730
2	Tulare.....	7,461
3	Porterville.....	6,374
4	Lindsay.....	4,661
6	Exeter.....	3,227
8	Woodlake.....	685
9	Strathmore.....	504
10	Tipton.....	424
11	Pixley.....	421
12	Farmersville.....	383
13	Springville.....	367
14	California Hot Springs.....	290
15	Terra Bella.....	290
16	Earlimart.....	268
18	Ivanhoe.....	240
19	Lemon Cove.....	240
20	Poplar.....	240
21	Tagus.....	240
23	Alpaugh.....	230
24	Woodville.....	206
28	Kaweah.....	120
29	Plano.....	120
30	Sequoia National Park.....	120
31	Tagus Ranch.....	120
32	Ducor.....	115
33	Goshen.....	115

* Data taken from statewide "Population Map" prepared by the Bur. of Agr. Econ.



LEGEND

- - 25 Farm Persons 1935
- - 25 Rural Non-Farm Persons 1935

○	100 to 250
○	250 to 500
○	500 to 1000
○	2000 to 4000
○	4000 to 8000
○	8000 to 16000

SOURCES OF DATA:

U. S. BUR. CENSUS - UNIV. CALIF. - BUR. AGR. ECON. - U. S. FOREST SERVICE -
 RAND MC NALLY & CO. - CALIF. TAXPAYERS ASS'N. - STATE DEPT. OF
 INSTITUTIONS - STATE CONTROLLER

— Boundary of Watershed
 - - - Boundary of Area affected by
 Water from Watersheds

POPULATION

E. I. Kotok, Chairman, Field Coordinating Committee No. 18
 Harry E. Reddick, Chairman, Field Coordinating Committee No. 20

U. S. DEPARTMENT OF AGRICULTURE
 FLOOD CONTROL PUBLIC NO. 738

Project No. 163 Map No. 3

Source of Data See list at left

Compiled by B. A. Econ. Date 1-38

Bureau Agricultural Economics

Approved *E. I. Kotok* Bureau U.S.F.S.
Harry E. Reddick S.C.S.

SOURCES OF DATA:
 RAND McNALLY & CO. - CALIF. TAXPAYERS ASSES - STATE B.
 U.S. BUR. CENSUS - UNIV. CALIF. - BUR. AGRI. ECON. - U.S. F.
 INSTITUTIONS - STATE CONTROLLER



LEG
 - 25 Farm Cor.
 - 25 Ranch Non



55	Cashen
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3	...
2	...
1	...

SACRAMENTO AND SAN JOAQUIN VALLEYS NO. 163
KAWEAH - TULE RIVER GROUPS
CALIFORNIA

AREAS SUBJECT TO FLOODS



LEGEND

- AREAS FLOODED IN 1937
- AREAS SUBJECT TO MAJOR FLOODS

— Boundary of Watershed
- - - Boundary of Area affected by Water from Watersheds

AREAS SUBJECT TO FLOODS

E. I. Kotok, Chairman, Field Coordinating Committee No. 18
Harry E. Reddick, Chairman, Field Coordinating Committee No. 20

U.S. DEPARTMENT OF AGRICULTURE
FLOOD CONTROL PUBLIC NO. 738

Project No. 163 Map No. 4

Source of Data U. S. War Department

Compiled by B. A. Econ. Date 2-38

Bureau Agricultural Economics

Approved *E. I. Kotok*
Harry E. Reddick

Bureau

U.S.F.S.
S.C.S.

SACRAMENTO AND SAN JOAQUIN VALLEYS NO. 163

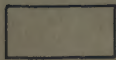
KAWEAH-TULE RIVER GROUPS

CALIFORNIA

LAND OWNERSHIP



LEGEND

-  NATIONAL FOREST
-  NATIONAL PARK
-  INDIAN RESERVATION
-  STATE LAND
-  PRIVATE LAND WITHIN NATIONAL FOREST BOUNDARIES
-  PRIVATE LAND OUTSIDE NATIONAL FOREST BOUNDARIES AND WITHIN WATERSHED BOUNDARIES

SOURCES OF DATA:

U. S. FOREST SERVICE — U. S. PARK SERVICE —
U. S. LAND OFFICE — STATE DIVISION OF PARKS —
UNIVERSITY OF CALIFORNIA — U. S. BUREAU OF INDIAN AFFAIRS

—— Boundary of Watershed
----- Boundary of Area affected by
Water from Watersheds

10 5 0 10
SCALE IN MILES

LAND OWNERSHIP

E. I. Kotok, Chairman, Field Coordinating Committee No. 18
Harry E. Reddick, Chairman, Field Coordinating Committee No. 20

U. S. DEPARTMENT OF AGRICULTURE
FLOOD CONTROL PUBLIC NO. 738

Project No. 163 Map No. 5

Source of Data See list at left

Compiled by B. A. Econ. — U.S.F.S. Date 3-38

Bureau AGRICULTURAL ECONOMICS

Approved *E. I. Kotok* Bureau U.S.F.S.
Harry E. Reddick S.C.S.

SACRAMENTO AND SAN JOAQUIN VALLEYS NO. 163

KAWEAH-TULE RIVER GROUPS

CALIFORNIA

IRRIGATION DISTRICTS AND AREAS UNDER IRRIGATION—1936

LEGEND

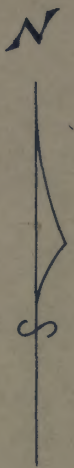


AREAS UNDER IRRIGATION
(Areas which are provided with irrigation facilities)

AREA COVERED BY



LEMOORE IRRIGATION DISTRICT
EMPIRE WEST SIDE IRRIGATION DISTRICT
LINDSAY-STRATHMORE IRRIGATION DISTRICT
TULARE IRRIGATION DISTRICT
CORCORAN IRRIGATION DISTRICT
LAKELAND IRRIGATION DISTRICT
TULARE LAKE BASIN WATER STORAGE DISTRICT
ALPAUGH IRRIGATION DISTRICT
VANDALIA IRRIGATION DISTRICT
TERRA BELLA IRRIGATION DISTRICT



10 5 0 10
SCALE IN MILES

SOURCES OF DATA:
STATE DIVISION WATER RESOURCES
UNIVERSITY OF CALIFORNIA
FEDERAL LAND BANK

— Boundary of Watershed
--- Boundary of Area affected by
Water from Watersheds

IRRIGATION DISTRICTS AND AREAS UNDER IRRIGATION—1936

E. I. Kotok, Chairman, Field Coordinating Committee No. 18
Harry E. Reddick, Chairman, Field Coordinating Committee No. 20

U.S. DEPARTMENT OF AGRICULTURE
FLOOD CONTROL PUBLIC NO. 738

Project No. 163 Map No. 6

Source of Data See list at left

Compiled by B. A. Econ Date 1-38

Bureau Agricultural Economics

Approved *E. I. Kotok* Bureau *Harry E. Reddick* U.S.F.S. S.C.S.

SACRAMENTO AND SAN JOAQUIN VALLEYS NO. 163

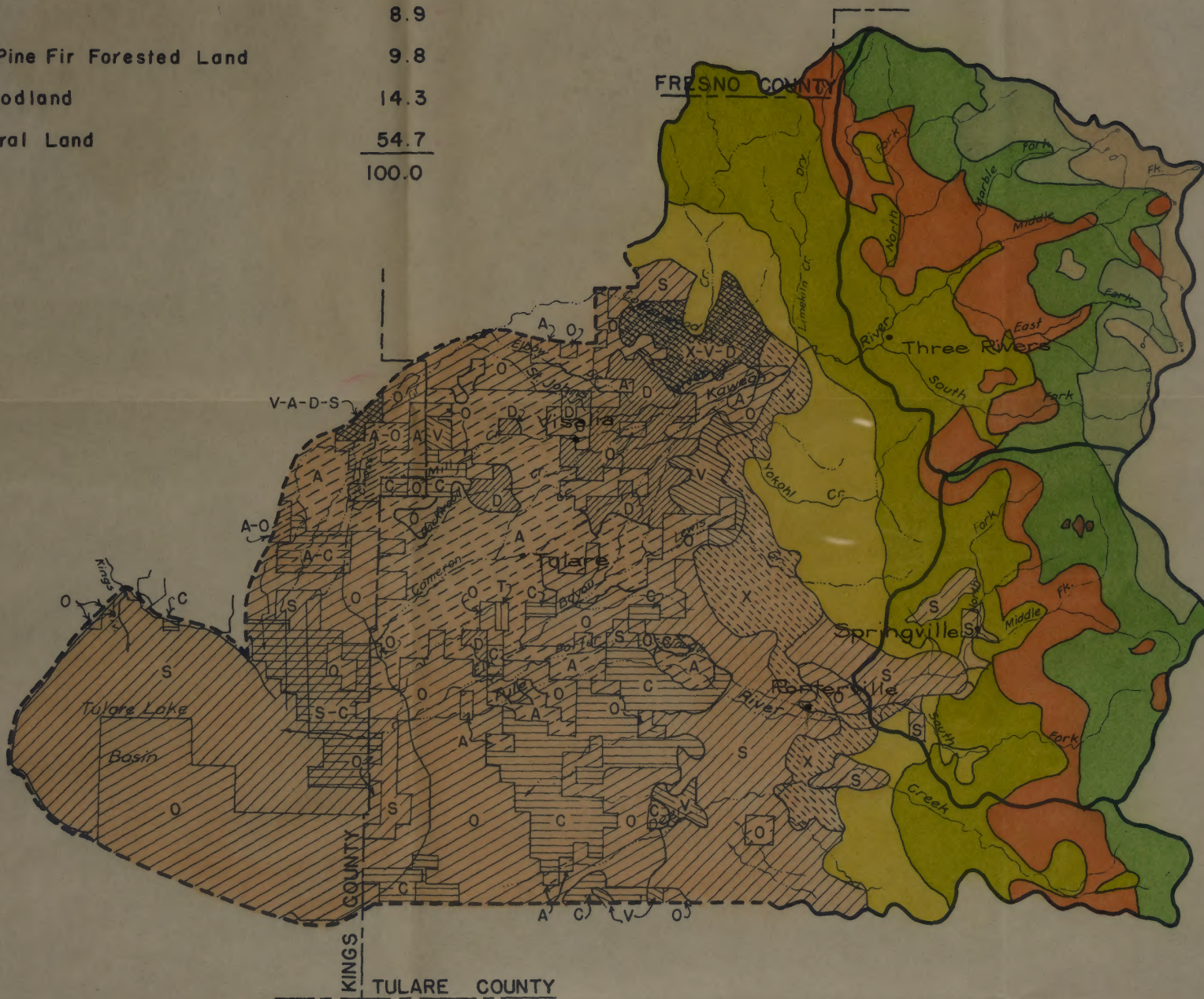
KAWEAH - TULE RIVER GROUPS

CALIFORNIA

TYPE OF FARMING AND NATURAL COVER

COVER TYPES 1937

TYPE	PERCENT TOTAL AREA
Cutover Land	0.0
Non-Commercial Rocky Forested Land	1.7
True Fir	3.4
Grassland	7.2
Brush	8.9
Pine & Pine Fir Forested Land	9.8
Open Woodland	14.3
Agricultural Land	54.7
	100.0



TYPE OF FARMING AREAS 1930

D	Deciduous Fruits, Nuts and Olives
X	Subtropical Fruits
V	Grapes
S	Small Grain
T	Row Crops
C	Cotton
A	Alfalfa - Dairy
O	Grazing - Beef or Sheep

TYPE OF FARMING AND NATURAL COVER

E. I. Kotok, Chairman, Field Coordinating Committee No. 18
Harry E. Reddick, Chairman, Field Coordinating Committee No. 20

U.S. DEPARTMENT OF AGRICULTURE
FLOOD CONTROL PUBLIC NO. 738

Project No. 163 Map No. 7

Source of Data U.C. - F.S. - S.C.S.

Compiled by B.A. Econ. Date 2-38

Bureau Agricultural Economics

Approved *E. I. Kotok* Bureau U.S.F.S.
Harry E. Reddick S.C.S.

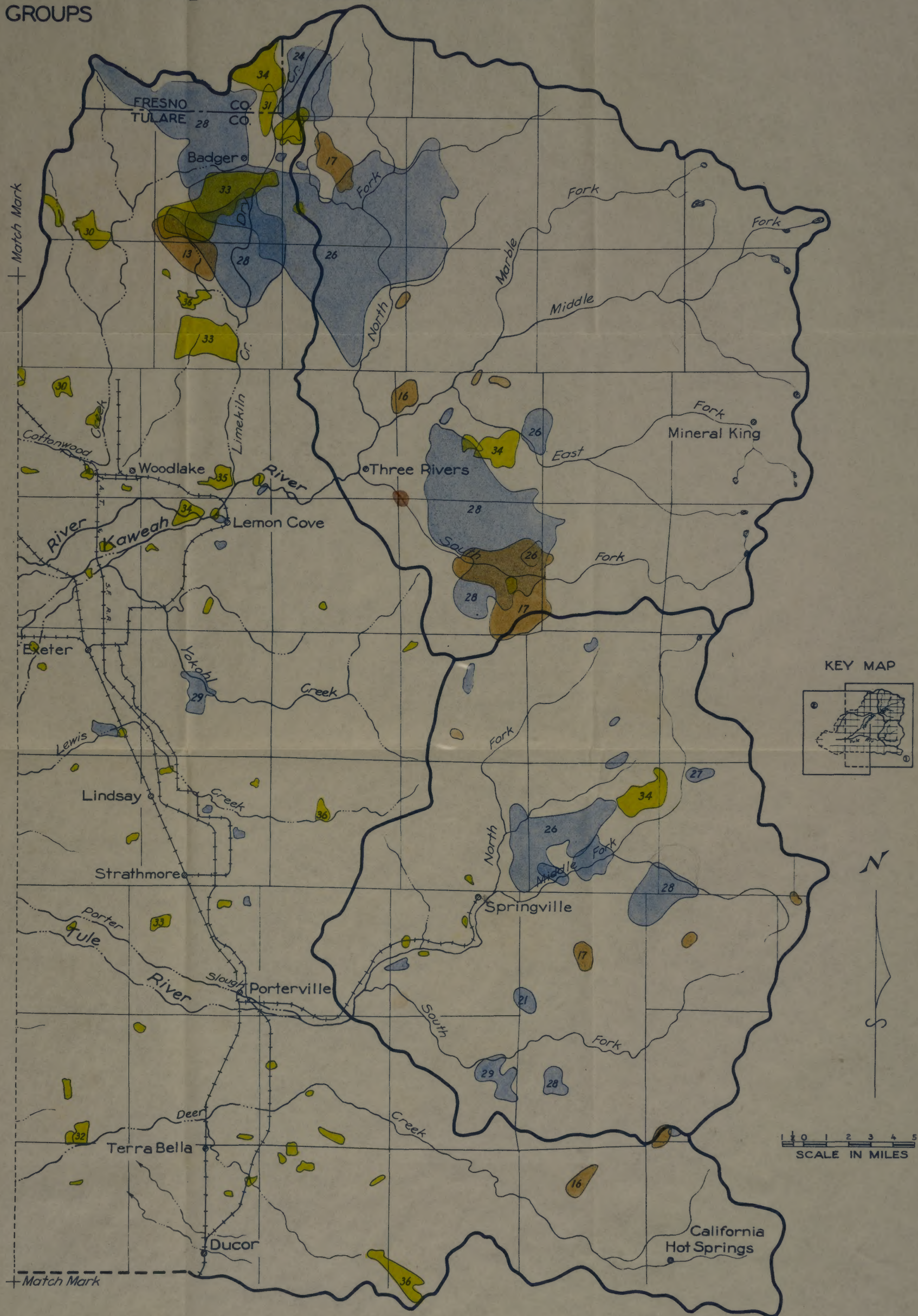
— Boundary of Watershed
--- Boundary of Area affected by
Water from Watersheds

SACRAMENTO AND SAN JOAQUIN VALLEYS NO. 163

KAWEAH-TULE RIVER GROUPS

CALIFORNIA

SHEET 1 OF 2



BURNED OVER AREAS

LEGEND

- FIRES 1910 - 20
- FIRES 1920 - 30
- FIRES 1930 - 40

- Boundary of Watershed
- Boundary of Area affected by Water from Watershed

E. I. Kotok, Chairman, Field Coordinating Committee No. 18
Harry E. Reddick, Chairman, Field Coordinating Committee No. 20

U.S. DEPARTMENT OF AGRICULTURE
FLOOD CONTROL PUBLIC NO. 738

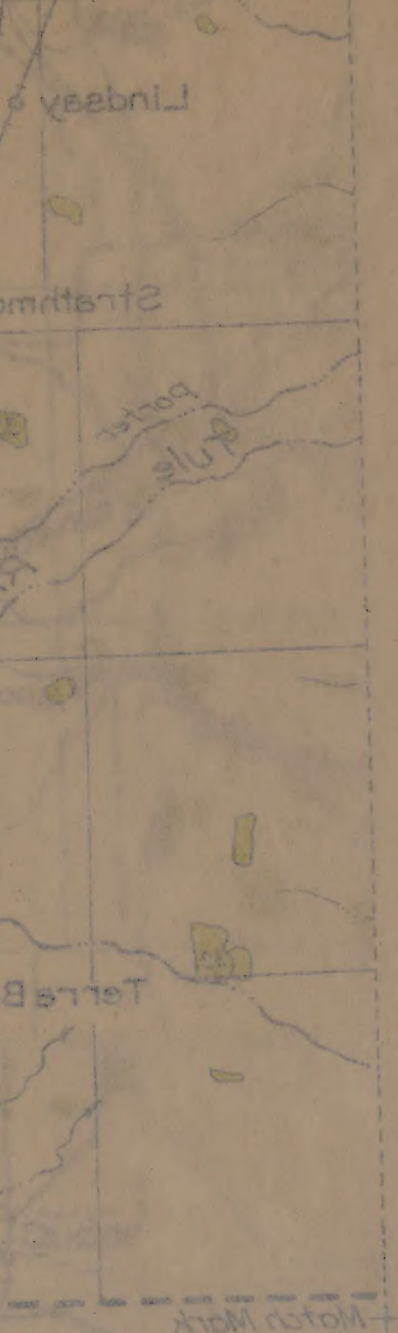
Project No. 163 Map No. 9

Source of Data U.S.F.S.-State Div. Forestry

Compiled by U.S.F.S. Date 1938

Bureau U.S.F.S.

Approved *E. I. Kotok* Bureau U.S.F.S.
Harry E. Reddick S.C.S.



BURNED OVER AREAS

LEGEND

FIRES 1910 - 20

FIRES 1920 - 30

FIRES 1930

